Solar Events Activity Key

*** For ease of use during class, the teacher key pages are numbered the same as the student book pages ***

I. Introduction

The sun gives us light and warmth, but it also gives us problems. The sun sends ions (charged atoms) and electrons into space at incredible speeds. When these particles interact with Earth's atmosphere, they cause several major problems ranging from power failures zapped satellites.

Continue with this activity to see how the sun is not only beneficial, but how it can be harmful.

Get Info Objectives

1. List effects of solar events.
2. Describe solar effects on human activities.
3. Describe solar effects on electric companies.

Gather Data Objectives

1. Describe the relationship of geomagnetic disturbances to solar events.
2. Use averaged solar data to determine the best time to debug electronic equipment.
3. Compute the diameter, escape velocity, and surface speed of the sun.

Application Objectives

1. Explain observations of the average sunspot number.
2. Justify the cost of an early warning system for geomagnetic storms.
3. Explain the international nature of solar event problems.

II. Get Info

A. General Information on Solar Problems

- Click on the "Solar Events" site.
- Read the information and answer the following question.

1. What problems do solar events cause ?

interrupt HF, VHF, UHF, LF, and VLF radio communications

interferes with geomagnetic surveys for minerals

pipelines corrode faster during geomagnetic storms

power grids could fail

satellites could get dragged into the atmosphere

and burn, satellite controls could be disrupted

astronauts could be injured or killed

Solar events produce the Aurora Borealis

- Click the "Back" button at the top of the screen in your web browser until you get back to the OAR Solar Events Get Info site.

B. Details of Solar Events

- Click on the "Space Environment" site.
- Scroll down to the "Coronal Holes" section.
- Read from "Coronal Holes" through the end of the site and answer the following questions as you read.

1. What effect do coronal holes have on the solar wind?

   Coronal holes increase the solar wind.

2. What types of energy do solar flares release?

   Gamma, X-ray, visible light, and radio waves

3. Aurora are also called the Northern Lights and Southern Lights. How are the lights formed?

   The Solar wind energizes electrons and ions in the magnetosphere. These particles usually enter the Earth's atmosphere near the polar regions. When the particles strike the molecules and atoms in the thin high atmosphere, some of them start to glow in different colors.

4. What causes geomagnetic storms on Earth?

   Portions of the solar wind's energy is transferred to the magnetosphere, causing the Earth's magnetic field to change rapidly in direction and intensity.

5. What does the ionosphere usually do to help communication that is changed by geomagnetic storms?

Portions of the solar wind's energy is transferred to the magnetosphere, causing the Earth's magnetic field to change rapidly in direction and intensity.

6. What dangers are there due to geomagnetic storms' disruption of the ionosphere?

Airline communication could be disrupted. Military Over the Horizon radar could be disrupted.

Planes and ships could incorrectly determine their positions.

7. How do geomagnetic storms affect satellites?

Storms cause the atmosphere to expand and drag the satellite into the air where it will burn up. Microchips that control the ship could be damaged, therefore the satellite could go out of control.

8. How can airlines be in danger due to geomagnetic storms?

They could lose radio communication with the ground.

They might not know where they are in relation to other planes or mountains and crash.

- Click "Back" until you get back to the OAR Solar Events Get Info site.
- Scroll down to section C.

C. Solar "Power" Problems

- Click on the "University of Michigan Power Grid" site.

1. Why do geomagnetic storms affect structures made by people more than they affect natural structures?

Igneous rock doesn't conduct electricity well. Current induced in the Earth by solar events travels through pipelines instead of through the rock layers.

- Click "Back" until you get back to the OAR Solar Events main screen.
- Click "Gather Data".

III. Gather Data

A. Solar Flares and Magnetic Disturbance

- Click on the "Solar Flare Effect" site.
- Scroll down to the graph.

1. Describe the relationship between X-ray radiation and the magnetic field variation.

X-ray flux and the magnetic field variation occur at the same time.

- Click "Back" until you get back to the OAR Solar Events Gather Data site.

B. Sunspots and Geomagnetic Storms

- Click on the "Occurrence of Geomagnetic Disturbances" site.
- Scroll down to the graph.

1. Describe the relationship between the sunspot number and the number of days with geomagnetic storms.

As the sunspot number increases, the number of days that have geomagnetic storms also rises. The number of storms rises after the sunspot number has peaked and is declining.

- Click "Back" until you get back to the OAR Solar Events Gather Data site.

C. Monthly Storms

- Click on the "Seasonal Distribution" site.
- Scroll down to the graph.

1. What two months have the highest average number of geomagnetic storms? March and April

2. What three months have the lowest average number of geomagnetic storms? January, December, July

3. Recalling the effects of geomagnetic storms, in what months would you want to test a new computer network?

January, December, July

4. Why did you choose these months?

Geomagnetic storms can cause power grid failure and can affect sensitive electronic equipment.

- Click "Back" until you get back to the OAR Solar Events Gather Data site.
- Click "Forward" at the bottom of the screen.

D. Annual Sunspot Numbers

- Click on the "Yearly Average Sunspot Numbers" site.
- Read the legend below the graph for help answering the question.

1. Yearly sunspot numbers have been calculated using the average of the daily number of sunspots. Which solar minimum year had the lowest yearly average? 1954 at 4.4

- Click "Back" until you get back to the OAR Solar Events Gather Data site.

E. Math Facts and Solar Measurements

- Click on the "Solar Facts" site.

1. The gravity on Earth is 9.8 meters per second per second. How much stronger is the gravity on the surface of the sun?

290 ÷ 9.8 = 29.6 times as much gravity on the sun as on the Earth

2. Escape velocity is how fast you have to go to escape the sun's gravity and not get sucked back into the sun. What is the escape velocity of the sun in kilometers per hour?

$$\frac{100\ m}{km} \times \frac{60\ min}{hour} \times \frac{60\ sec}{minute} \times \frac{618{,}000\ m}{second} = 2.2248 \times 10^{12}\ km/hr$$

3. What is the diameter of the sun? 1.4×10^9 meters

$7 \times 10^8 \times 2 = 1.4 \times 10^9$ meters

4. Use the diameter you found in question 3 to find the circumference of the sun. ($C = \pi d$)

$C = \pi d\ (3.14 \times d)$
$C = 3.14 \times 1.4 \times 10^9$ meters
$C = 4.396 \times 10^9$ meters

5. Use the rotation period of the sun, the number of hours in a day, the number of meters in a kilometer, and the circumference of the sun to figure out what the surface speed of the sun is in kilometers per hour. (How fast is it moving on the surface?)

$$\frac{1 \text{ day}}{24 \text{ hours}} \times \frac{1 \text{ revolution}}{27.3 \text{ days}} \times \frac{4.396 \times 10^9 \text{ m}}{\text{revolution}} \times \frac{1 \text{ km}}{1000 \text{ m}} = 6{,}709 \text{ km/hr}$$

6. Use the fact that there are about 1.6 kilometers per mile to convert the speed you found in question 5 to miles per hour.

4, 193 miles per hour

- Click "Back" until you get back to the OAR Solar Events site main screen.

IV.

A. Variation

- Click on the "Variation" site.
- The "aa" index is used to measure the geomagnetic disturbances on Earth.

1. What does the graph seem to tell us about the average number of geomagnetic disturbances? The number is increasing.

2. Besides the explanation that there are more disturbances, what other explanation is possible to explain the fact that the number of disturbances measured is increasing?

We are building better instruments to observe sunspots so we see more of the sun.

- Click "Back" until you get back to the OAR Solar Events Application site.

B. Cost vs. Cost

- Click on the "University of Michigan Solar Storm Cost" site.

1. What kinds of problems can be avoided if power companies get early warnings of coming geomagnetic storms?

Public transportation that uses electricity for power would stop. Security systems would be shut down. Heating and cooling systems would be shut down.

- Click "Back" until you get back to the OAR Solar Events Application site.
- Click on the "Start-Up Problem" site.

2. Why should you turn off your electric appliances whenever there is a power failure?

The power demand at startup is much greater than the normal operating power demand.

- Click "Back" until you get back to the OAR Solar Events Application site.

C. International Accord

1. Explain why the cost of maintaining an early warning system for geomagnetic storms is justified.

The cost of not having a warning system could be millions of dollars and human lives.

2. Why should all industrialized nations work together to set up the warning system?

All industrialized nations have power grids, shipping interests, and airlines. They all use radio communications, so they should all help keep the system operational. The system needs to be monitored from several places on Earth to be most effective.

- Click "Back" until you get back to the OAR Solar Events main screen.
- Click "Enrichment."

V. Enrichment Activities

A. Research

1. Research the Aurora Borealis. Find out when, where, and how they occur. Draw a diagram showing the areas on Earth where they occur most often.

2. Research when the next solar eclipse will be. What locations on Earth will see a total eclipse? a partial eclipse?

3. Research Earth's escape velocity. What is it and how is it different from the Sun's escape velocity? Ideally, satellites would be launched from the equator. What difference does it make where you launch a satellite from?

4. Find out about ancient cultures and how they created calendars and measured time based on the sun.

B. Interviews

1. Interview an astronomer at a local planetarium about locally-seen eclipses.

2. Work in groups and list all the songs you can think of that mention the sun.

C. Related Web Sites

1. NASA eclipse page
   http://umbra.nascom.nasa.gov/eclipse/
2. List of 1998 eclipses, meteor showers, and other phenomena
   http://www.sec.noaa.gov/ises/calendar/1998igc1.html
3. List of eclipses for the next ten years
   http://www.ips.gov.au/papers/richard/solar_eclipse.html
4. National Geophysical Data Center site on geomagnetic data
   http://www.ngdc.noaa.gov/seg/potfld/geomag.html
5. Technically oriented National Geophysical Data Center site on cosmic rays
   http://www.ngdc.noaa.gov/stp/SOLAR/COSMIC_RAYS/cosmic.html